

## Claims

What is claimed is:

1. A cooling apparatus for an electronic module, said electronic module having a substantially vertical orientation, said cooling apparatus comprising:

an evaporator with a surface for making thermal contact with said electronic module;

a boiling chamber within said evaporator, said boiling chamber having a plurality of fluid inlet ports disposed proximate one end of said boiling chamber, said boiling chamber having a plurality of fluid outlet ports disposed proximate an opposing end of said boiling chamber; and

a condenser having a plurality of tubes, each of said plurality of tubes being in fluid flow communication with one of said plurality of fluid outlet ports and one of said plurality of fluid inlet ports, said condenser further having a heat exchanger, said heat exchanger having a plurality of thermally conductive fins, each of said plurality of fins being in thermal contact with one or more of said plurality of tubes;

a plurality of check valves, each of said check valves being disposed within a fluid flow path in proximity to one of said boiling chamber inlet ports, each of said check valves being oriented to allow fluid flow from said tube to said boiling chamber while prohibiting fluid flow from said boiling chamber into said tube.

2. The apparatus of claim 1, further comprising a cooling fluid.

3. The apparatus of claim 2, wherein said cooling fluid is selected from the group consisting of water, brine, and dielectric fluids.

4. The apparatus of claim 3, wherein said dielectric fluid is a refrigerant.

5. The apparatus of claim 2, wherein said cooling fluid is at a pressure below atmospheric pressure.

6. The apparatus of claim 1, further comprising one or more extended heat transfer surfaces in thermal contact with said evaporator surface for making thermal contact with said electronic module.
7. The apparatus of claim 6, further comprising one or more vapor deflectors disposed proximate at least one of said one or more extended heat transfer surfaces.
8. The apparatus of claim 1, wherein said boiling chamber edges are rounded in shape.
9. The apparatus of claim 1, wherein the thickness of said boiling chamber is greater near said fluid outlet ports than near said fluid inlet ports.
10. The apparatus of claim 2, wherein said plurality of tubes are pitched to improve gravity induced flow of said cooling fluid when said electronic module is oriented other than vertically.

12. A fluid-cooled electronic apparatus, comprising:

an electronic module, said electronic module having a substantially vertical orientation;

an evaporator in thermal contact with said electronic module;

a boiling chamber within said evaporator, said boiling chamber having a plurality of fluid inlet ports disposed proximate one end of said boiling chamber, said boiling chamber having a plurality of fluid outlet ports disposed proximate an opposing end of said boiling chamber;

a condenser comprising a plurality of tubes, each of said plurality of tubes being in fluid flow communication with one of said plurality of fluid outlet ports and one of said plurality of fluid inlet ports, said condenser further comprising a heat exchanger, said heat exchanger comprising a plurality of thermally conductive fins, each of said plurality of fins being in thermal contact with one or more of said plurality of tubes;

a plurality of check valves, each of said check valves being disposed within a fluid flow path in proximity to one of said boiling chamber inlet ports, each of said check valves being oriented to allow fluid flow from said tube to said boiling chamber while prohibiting fluid flow from said boiling chamber into said tube.

13. The apparatus of claim 12, further comprising a cooling fluid.

14. The apparatus of claim 12, wherein said cooling fluid is selected from the group consisting of water, brine, and dielectric fluids.

15. The apparatus of claim 12, wherein said dielectric fluid is a refrigerant.

16. The apparatus of claim 12, wherein said cooling fluid is at a pressure below atmospheric pressure.

17. The apparatus of claim 12, further comprising one or more extended heat transfer surfaces in thermal contact with said evaporator surface for making thermal contact with said electronic module.

18. The apparatus of claim 17, further comprising one or more vapor deflectors disposed proximate at least one of said one or more extended heat transfer surfaces.
19. The apparatus of claim 12, wherein said boiling chamber edges are rounded in shape.
20. The apparatus of claim 12, wherein the thickness of said boiling chamber is greater near said fluid outlet ports than near said fluid inlet ports.
21. The apparatus of claim 12, wherein said electronic module is oriented other than horizontally.
22. The apparatus of claim 12, wherein said evaporator and condenser form a unit, said unit being detachable from said electronic device.
23. The apparatus of claim 12, wherein said cooling fluid is in substantially direct thermal contact with said electronic module.

25. A cooling assembly for an electronic module, said cooling assembly comprising:

an evaporator with a surface for making thermal contact with said electronic module;

a boiling chamber within said evaporator, said boiling chamber having a plurality of fluid inlet ports disposed proximate one end of said boiling chamber, said boiling chamber having a plurality of fluid outlet ports disposed proximate an opposing end of said boiling chamber;

a condenser comprising a plurality of tubes, each of said plurality of tubes being in fluid flow communication with one of said plurality of fluid outlet ports and one of said plurality of fluid inlet ports, said condenser further comprising a heat exchanger, said heat exchanger comprising a plurality of thermally conductive fins, each of said plurality of fins being in thermal contact with one or more of said plurality of tubes;

a plurality of check valves, each of said check valves being disposed within a fluid flow path in proximity to one of said boiling chamber inlet ports, each of said check valves being oriented to allow fluid flow from said tube to said boiling chamber while prohibiting fluid flow from said boiling chamber into said tube;

an air moving device, capable of causing air to flow through said condenser;

a plurality of baffles, capable of directing airflow through said condenser.

26. The assembly of claim 25, further comprising a cooling fluid.

27. The assembly of claim 26, wherein said cooling fluid is selected from the group consisting of water, brine, and refrigerant.

28. The assembly of claim 26, wherein said cooling fluid is at a pressure below atmospheric pressure.

29. The assembly of claim 25, wherein said plurality of baffles form a plurality of air inlets.

30. The assembly of claim 29, wherein said plurality of air inlets are distributed along the direction of airflow through said condenser.

31. The assembly of claim 25, further comprising a plurality of check valves, each of said check valves being disposed within a fluid flow path in proximity to one of said boiling chamber inlet ports, each of said check valves being oriented to allow fluid flow from said tube to said boiling chamber while prohibiting fluid flow from said boiling chamber into said tube.

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